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WHEY— a problem and a potential

By NANDOR PORGES

WHAT ABOUT whey? Approximately 9 lbs. of liquid whey remains for each pound of cheese manufactured, thus there is a great deal of whey produced by cheesemakers. Somewhat more than 1.36 billion lbs. of cured cheese, including about 75 million lbs. of cream cheese and almost 6 million lbs. of Neufchatel cheese, are made in the United States (1). This yields about 12.3 billion lbs. of whey, of which only about 3.4 billion lbs. are processed (2). The remaining 8.9 billion lbs. of liquid whey contain 430 million lbs. of sugar and 80 million lbs. of protein. Some of this liquid is taken back to the farms, but most of it poses an important problem for the 1,785 (plus or minus) cheese manufacturing plants. Since a 10,000-lb. vat yields 9,000 lbs. of whey, each cheese manufacturer knows the amount of whey he must handle, although the estimated average for the country is only about 12,500 lbs. of liquid whey daily.

We must add the whey resulting from the production of almost a billion lbs. of curd and creamed cottage cheese and from the 3 million lbs. of casein produced annually. As Dr. Walter Price pointed out at the Wisconsin Dairy Manufacturers' Conference (3), there are fewer plants today than in 1955, when the above information was compiled. But then, each would have a little more whey, since cheese production has not decreased.

Composition of Milk and Whey. Let us look at this problem a little differently. Milk, the raw product, contains about 4 per cent fat, 5 per cent lactose, 3 per cent protein and 0.7 per cent ash. This gives a total solids content approaching 13 per cent in whole milk. The greenish yellow fluid, whey, remaining after cheese-making and after removal of residual fat, contains almost 7 per cent solids, having the following average composition: trace of fat, 4.9 per cent lactose, 0.9 per cent protein, 0.6 per cent ash, and 0.2 per cent lactic acid (2). Thus, in making cheese, about two-thirds of the protein has been removed from the milk as well as all the fat, but practically none of the sugar. We still have left one-half of the original raw product. It is this 50 per cent of potentially valuable material that is generally discarded as a waste. At present, I am unaware of any other industry that discards one-half its solids in order to recover the other half.

Disposal of Whey as Waste. Currently, this unused whey is a problem. In fact, it is an expense to many cheese producers. It must be collected, given away, hauled away or be treated as a waste material. At the Pacific Northwest Industrial Waste Conference held at Pullman, Washington, April 4

"The practices of disposal are not the practices of thrift." This centrifuge, developed by the De Laval Separator Company, is part of a system designed to recover most of the solids from whey. It is being used by Graoc Dairy in East Aurora, New York.

and 5, 1957, some dairymen told me that they pay 2 to 6 cents a 100 lbs. to haul this waste whey from their plants to a distant authorized dumping ground in a deep ravine. (It must be a long distance from the city and on the leeward side of the town.) The waste problem still exists, since the state authorities are considering the banning of such dumping.

Therefore, until more extensive uses are found for whey, it is necessary to have a better understanding of the treatment of whey wastes for disposal. Our laboratory has been assigned this whey problem. The disposal of whey as waste by biochemical oxidation can be accomplished under certain conditions, especially if the whey is diluted. True, such treatment cannot be done for nothing and must be considered as an additional cost in the manufacturing of cheese.

Oxygen Requirements. Under proper conditions of aeration and nutrition, the liquid, just like other dairy waste, can be stabilized in the form of removable sludge cells and relatively harmless liquid (4). The adverse effect of whey on streams, in sewage treatment plants and on soil is caused by its high oxygen demand. For example, we can calculate the amount of oxygen required by 100 lbs. of whey containing 4.9 per cent sugar, 0.9 per cent protein and 0.2 per cent lactic acid. Each pound of milk sugar needs 1.07 lbs. oxygen for complete combustion; protein, 1.44 lbs.; and lactic acid, 1.07 lbs. Therefore,

100 lb. liquid whey + oxygen =
4.9 lb. sugar + 5.29 lb. O_2
0.9 lb. protein + 1.29 lb. O_2
0.2 lb. lactic acid + 0.21 lb. O_2
or 6 lb. whey organic matter + 6.8 lb. O_2 = CO_2 + H_2O + NH_3

The conversion of this organic matter to microbial cells utilizes only about 40 per cent of this calculated amount of oxygen or 2.7 lbs. Since 58-60 cu. ft. of air contains 1 lb. of oxygen, the supplying of this amount of oxygen at the required rates would be easy if all the oxygen in the air were used. Unfortunately, only 1, 2, 5, or up to 25 per cent of the oxygen in the air may be forced into solution depending upon the type of aeration device used. (5). Thus, with equipment having a 2 per cent oxygen transfer efficiency, the 2.7 lbs. O_2 will require 2.7 × 60 × 50 = 8,100 cu. ft. air. Additional oxygen must also be supplied for the life processes of the cells. Data and calculations are available for designing a plant for the aerobic treatment of dairy wastes (6). It is our understanding that over 60 units are in operation.

SCIENTIST AND AUTHOR

Nandor Porges, a native of Hungary, came to this country at an early age. He studied at Massachusetts Agricultural College, now the University of Massachusetts. He spent most of his business life in government service. For a number of years he had been with the Eastern Utilization Research and Development Division of the USDA's Agricultural Research Service. His studies on whey made him one of the nation's outstanding authorities on the subject. Because of the high quality of his work in this area and because he contributed so much to the application of the scientific method and mind to the dairy industry, his untimely death early this year is a great loss to the industry he served so well. The extensive discussion of whey that is printed here was first presented by Mr. Porges at the annual Wisconsin Dairy Manufacturers Conference at the University of Wisconsin in February, 1958.

Spray Irrigation. Irrigation of the waste on land is under study through a cooperative contract arrangement between our Laboratory and the University of Wisconsin. Dr. Rohlich of Sanitary Engineering and Dr. Engelbert of Soils are making excellent strides (7). Here again the study is limited to dilute whey wastes. Information is becoming available as to the amount of liquid that can be sprayed on different soils. A good top soil seems of great importance. Also, the water treatment capacity is related to the most impervious layer or soil horizon. The destructive effect of salt on the soil is being followed. Too much salt enters the waste from whey drippings and spillage during cheese-making. Apparently, also, cheese-makers listen to cigarette advertisements, since the researchers on this study are being bothered by the clogging of spray nozzles by the filter tips of cigarettes. This spray irrigation study is yielding interesting and valuable data.

Whey Products. The practices of disposal, however, are not the practices of thrift. "Gather up the fragments that remain that nothing be lost," the Scriptures admonish in John 6:12. In their book, "By-products from Milk," Whittier and Webb (2) list many products derived from pasteurized, concentrated or fermented whey, as well as some of their uses. Unfortunately, the products actually made are not as impressive as the list suggests.

Pasteurized Whey:
- Whey Cream
  - whey butter

Concentrated Whey:
- Whey Proteins
  - protein hydrolyzates
  - cheese
  - cheese spreads
  - feed
  - bakery products

Pasteurized Sweet Whey:
- whey drinks
- soups

Dried & Condensed Whey:
- soups
- cheese spreads
- feed
- bakery products
- candy

Sweetened Condensed Whey:
- bakery products
- candy

Fermented Whey:
- Riboflavin
  - feed concentrates
- Ethyl Alcohol
  - vinegar
- Yeast
  - feed
- Lactose
  - candy
  - infant foods
  - lactose syrup
  - pills
  - penicillin
- Butyl Alcohol-Acetone
  - solvents
  - paints
- Lactic Acid
  - food acidulant
  - resins, coatings
  - tanning
  - plastics

Whey as Feed. The success obtained by feeding urea to ruminants has led to wider adoption of such supplementation (8). The rumen bacteria can use this type of nitrogen in the process of breakdown of the carbohydrates within the animal. It would seem that whey, especially in the concentrated or dry form, could be utilized in this way with the addition of nitrogen. If this were so, a ready market is right at hand. However, study will be needed to determine the proper amount of nitrogren to add. Also,

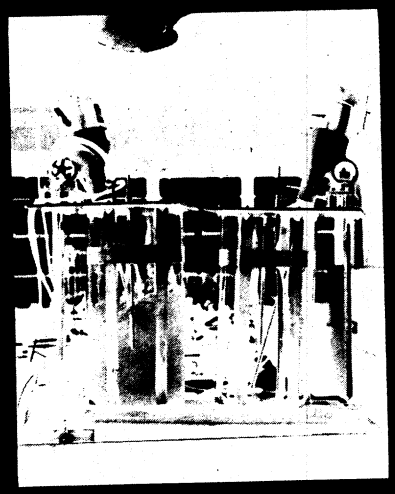
the availability of the whey solids should be studied in relation to their utilization in the presence of nitrogen and as to their effects on the animal. For example, there is a great insufficiency of nitrogen. The 6 lbs. organic matter in the 100 lbs. fresh whey contains only about 0.15 lb. nitrogen. Since carbon and nitrogen are two important elements for growth, let's compare the approximate carbon to nitrogen ratio of some common substances with that of whey. Protein products have a narrow carbon to nitrogen ratio.

	C	to	N
Milk, whole	14.5	:	1
Milk, skim	7.8	:	1
Casein	3.3	:	1
Cheese	8.0	:	1
Eggs	8.8	:	1
Sirloin	8.2	:	1
Bacteria	4.3	:	1
Whey	15.5	:	1

The use of molasses for the preservation of protein-rich green crops is an accepted practice. About 40 lbs. of molasses are added to a ton of fodder to obtain rapid desirable acidification. Whey molasses or concentrated whey serves as an excellent source for the formation of lactic acid in ensilage (9). More whey should find a use in this manner.

Lactose as a Raw Chemical. The possibility of using lactose as a raw chemical material may have some merit. It may be possible to use fluid whey directly rather than pure lactose. Sugar chemists know that under proper conditions, sugar is capable of reacting with a wide variety of organic compounds. Sugar can be chemically oxidized, chemically reduced; it can be acted upon by acids or by alkalis. Over 3,000 derivatives have been listed using sucrose and other sugars as one of the reactive chemicals (10). It would be of interest to know what derivatives can be obtained from lactose that may be of practical value.

Considerable information has been published on the use of sugar and sugar by-products in the plastics industry. Sugar itself may be an integral part, as much as 25 per cent, of the molding powder (11). Allyl ethers of sucrose have been produced that are plastic resins



Fermentors used at the Eastern Laboratory for the experimental production of yeast from whey.

of desirable properties. Sugar itself may be used as a plasticizer in coatings used on paper, cloth, wood, etc. Can lactose offer some superior properties?

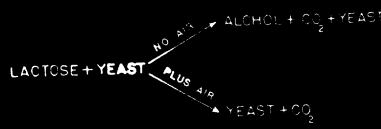
Fermentation Products. The third type of processing, fermentation, can also offer some interesting possibilities for using whey. Currently, little whey is being used in fermentation processes, probably due to the economic situation.

Riboflavin (Vitamin B-2) has been produced by the anaerobic fermentation of whey using a bacterial culture of *Clostridium acetobutylicum*, details of which are given in various patents and reviewed by Whittier and Webb (2). About 2.5 grams riboflavin are synthesized per 100 lbs. liquid whey to supplement the 0.06 gram originally present. The dried product contains about 90 grams per 100 lbs. and may be added to chick feeds. The solvents butyl alcohol and acetone were recovered also. Another method using a fungus gives much higher yields with grain and sugar media (12). This is a primary fermentation to yield riboflavin and its possibilities with whey have been shown (13).

Ethyl alcohol can be readily produced from whey by use of a lactose-fermenting yeast (2). Under present economical conditions, this is not a paying process even though the alcohol recovered may be about 40 to 50 per cent of the weight of lactose in the whey.

By changing the conditions of growth and supplying oxygen, the yeast, instead of producing alcohol, forms more yeast cells. The expense involved in acidifying the whey, removal of the protein, sterilization and aeration caused this process to be abandoned.

Yeast. However, this conversion of whey to yeast solids is worthy of restudy because of the current prices of yeast. Preliminary work done in our laboratory by Dr. Wasserman and Mr. Hopkins shows that the solubles in cheese whey may be converted to removable solid material in as short a time as 4 hours (14). Prior treatment or sterilization of the whey was unnecessary. These results were accomplished by supplying a mass inoculum for seed and supplying proper aeration. Almost theoretical yields of yeasts were obtained, about 50 per cent, based on the weight of whey solids. The following shows the action of yeast on lactose. In the absence of air, a small quantity of yeast is formed, but large amounts of alcohol. In the presence of air, a large amount of yeast is obtained instead of the alcohol.



Lactose-free Product. A whey product, currently sold on the market, is high in vitamins. In its preparation, the vitamins of the whey are concentrated by fermenting the lactose with a yeast. The resulting lactose-free beer is then concentrated, dried and marketed as a feed supplement (15).

Lactic Acid. Lactic acid is produced from whey by the action of a strain of *Lactobacillus bulgaricus* and requires about 42 hours for completion of the fermentation. Lactic acid of various grades is prepared as well as lactates.

What other products can we expect?

Vitamin B-12. We have shown the presence of Vitamin B-12 in wastes (16). Possibly if the right conditions were established, whey itself may serve as a medium for

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TABLE 1: SALES RESULTS WITH SPECIALTY PRODUCT PROMOTIONS

	Month	Regular Pkg. Unit Sales	Additional Premium Item Sales	Per Cent Increase
Dairy "A"	September	2,667		
	October	2,660	1,820	68.4
	November	2,300	1,876	85.9
	December	2,300	716	31.1
	January	2,453		
Dairy "B"	September	8,000		
	October	7,200	7,425	103.1
	November	6,800	6,150	90.4
	December	7,100	1,000	14.1
	January	7,410		
Dairy "C"	September	1,683		
	October	1,656	1,668	100.7
	November	1,632	1,495	91.6
	December	1,584	921	58.1
	January	1,560		

created by offering a quality premium with a quality product will insure customer satisfaction and go far toward making repeat users of trial buyers.

Steady sales increases are being shown by another dairy specialty – sour cream – as the American public "discovers" new ways to use it. The big boost in its popularity is attributed to Arthur Godfrey's aired suggestion for making a potato chip dip with sour cream and Lipton's onion soup mix. Now dairies and chain stores are packing and promoting a similar dip and their marketing groups will provide the stimulus for steady sales progress.

Extensive promotions of this nature require the touch of an experienced merchandising man. This is the job of the marketing director. He selects the proper markets or areas within a market most likely to respond to a merchandising push. He designs the program and puts it into operation.

Regardless of the size of your company and whether or not steps have been taken to create a marketing department headed by a qualified director, it is hoped that this article will stimulate thinking along that line for future planning. The specific examples of product promotions show how cooperation between marketing specialists and sales can account for increased volume and pave the way for public acceptance of a new item.

The dairy industry, in my opinion, is slated for more changes which will come at a faster pace, than most other major industries. Again and again it has been demonstrated that sound management is the key to the problem of adjusting to changing times. The position of marketing director is a response to the sales challenge of our generation.

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THE PROBLEM OF WHEY

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producing this essential vitamin. It will be necessary to determine whether to use pure cultures or crude cultures and the type of supplementation needed in this aerobic fermentation. The vitamin has been obtained by Leviton and Hargrove (17) through microbial synthesis using a bacterium isolated from cheese. Certain *Streptomyces* also produce this vitamin (18). Further research on this process using whey is planned in our Laboratory.

Gluconate. Another possible fermentation depends upon the structure of lactose, which can yield glucose and galactose. It may be possible, by establishing proper conditions, to produce gluconic acid and galactose. The gluconic acid is recoverable as sodium gluconate and may find application in the cleaning of dairy utensils. Thus, the dairy waste, whey, may give a product of value to the dairy industry.

Enzymes. Various organisms produce the enzyme, glucose oxidase. One practical use of this enzyme is in the preparation of dried egg whites (19). It destroys the traces of glucose in the egg and thus prevents browning during drying of the white product. Can this enzyme be produced also in the fermentation of lactose?

The possibility of obtaining low-cost lactase from whey is being considered by our group. This enzyme splits the lactose to glucose and galactose, sugars sweeter than lactose and more soluble. Lactose thus treated should find a use in ice cream, as it would not tend to crystallize. Currently, lactase is unavailable in commercial quantities at reasonable prices.

Various other enzymes may also be produced, depending upon whether yeast, molds or bacteria are used to convert or act upon the whey.

Peroxide Studies. Of course, there is the problem of transporting the whey, in as natural a condition as possible, from the cheese manufacturers to the central whey processing plant. Miss Jasewicz of our laboratory is investigating the use of the addition of small quantities of hydrogen peroxide to prevent spoilage of whey during shipment. Prior to processing the whey, the hydrogen peroxide is destroyed by the addition of catalase. Current investigations appear promising that microbial fermentations can be continued after such peroxide-catalase treatment. Similar studies have been reported on the treatment of milk for cheese (20).

We are also conducting a study pertaining to the use of hydrogen peroxide as a source of oxygen in the growing of cells in whey, amplifying some preliminary work done by Dr. Wolnak of the Mid-West Laboratories, Chicago, along these lines. The possible applications are not known at present.

In short, cheesemakers have a potentially valuable and renewable source of carbohydrate in the waste whey. Important uses might be developed for whey or for whey products.

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Chocolate Milk Consumption On the Upswing

INFORMAL REGIONAL surveys of dairy plant operators indicate that sales of chocolate milk and chocolate drink so far this year are on the rise. The Chocolate Milk Foundation reports that their informal surveys of dairy plant operators in various sections of the country indicate that dairies that do back the product with adequate promotion have enjoyed healthy sales increases. One Midwest dairy reported that unit home delivery sales of dairy chocolate were running 4.68 per cent ahead of last year, while total unit sales were showing a 15.89 per cent gain. "The biggest part of this gain resulted from increased sales to schools this year," he said.

Many dairies, formerly indifferent to chocolate milk, have become aware of its potential and are backing the product with newspaper ads and in-store demonstrations.

A drop in consumption of chocolate milk took place between 1957 and 1958 – from 4.1 to 3.6 quarts – according to the latest National Dairy Council study, entitled "How Americans Use Their Dairy Foods." In 1958, Americans drank about 4 quarts of chocolate flavored nonfat milk per person annually, a figure which has remained constant over the past several years.

Manufacturers of chocolate products for the dairy industry, queried by the *American Milk Review and Milk Plant Monthly*, have expressed varying attitudes regarding the NDC statistics. Some have indicated that their sales figures do not parallel the decline, but the majority have been aware of a falling off in chocolate milk consumption. One chocolate supplier surmised that chocolate milk use is closer to 3.8 than 3.6 quarts per person.

The suppliers speculate that the apparent decline of interest by consumers in dairy chocolate may be the result of some dairies "cheapening" the process to cut costs, using inferior milk products with off taste. "Chocolate drinks" with low butterfat content may also have disillusioned the consuming public. Step up the quality of the product and then be sure your customers know about it the suppliers advise.

Do-It-Yourself Promotion

Another factor which may be responsible for inroads into dairy sales may be the high-pressure promotion of syrups and powders such as Bosco, Nestle, Cocoa Marsh and others which permit the housewife to make her own chocolate milk. The chocolate products manufacturers noted that the advertising and promotion programs for these store-bought powders and syrups have been greatly stepped up and have been rewarded with a tremendous increase in sales to consumers.

The vice-president of one large